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Teaching a one-credit course on data literacy and data visualisation

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Abstract

Data literacy skills are becoming critical in today's world as the quantity of data grows exponentially and becomes the 'currency' of power. In spring 2020, a team of two librarians piloted a new one-credit course in data literacy and data visualisation. This report explains the rationale behind the project and discusses the place of data literacy within information literacy (IL) instruction. The authors describe the pilot's learning objectives, topics covered, course design, the structure of assignments and the delivery of the course. They analyse the feedback received on the course and suggest ways to refine their practice.

The article calls for a re-envisaging of the library's role in data literacy instruction. It aims to address how librarians can extend their current practice of teaching IL to data literacy and why it is important. The authors' experience may inspire other academic librarians to incorporate data literacy and data visualisation into their teaching practice.

Keywords

curriculum design; data visualisation; data literacy; digital literacy; information literacy; Qatar; teaching

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1. Introduction

In today's world, the quantity of and access to data (we define data as information that can be described categorically or numerically and organised into larger datasets for reference and analysis) are growing exponentially. Our data-rich information landscape poses a distinct challenge for students: How can undergraduates become proficient and responsible users of the data that they encounter in their studies or produce as part of their research? This challenge is nothing to take lightly and requires serious engagement at all levels of academia. The library is a key player in addressing this issue. Librarians, building on their expert knowledge of information literacy (IL), are in an ideal position to develop and share their expertise in this area. Through focused instruction, the library can empower students with data literacy skills that will benefit them in their subsequent coursework and careers.

The innovative teaching practice described in this report offers a way to address the issue and help students gain these critical data literacy skills. Based on a review of the existing literature, we define data literacy as the ability to find, analyse, interpret and effectively communicate data and key insights derived from it. At Georgetown University in Qatar (GU-Q), an undergraduate institution offering a Bachelor of Science in Foreign Service degree to about 350 students, data literacy and its associated fields of knowledge, such as data collection and organisation, data management, data analysis, and data visualisation are not taught in a systematic way. Only

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very few courses – Economics in particular – call for data-related assignments. In some Economics courses, faculty introduce students to R and SPSS (a programming language and a software package used in statistical analysis), but they are short of time to teach the foundational concepts of data literacy. The expectation is that on arrival in class students have sufficient knowledge and experience of using Excel, Google Sheets, and data visualisation software. The gap between faculty expectations and students' inadequate knowledge in this area then becomes an issue and a source of frustration for both parties.

To address the problem, two GU-Q librarians teamed up in spring 2020 to pilot a one-credit course in data literacy and data visualisation. The objectives were to give students a chance to learn important data literacy concepts, build practical skills by working hands-on with data and data visualisation software, and fill the existing knowledge gap.

In this article, we share our experience about how we approached the development of the one-credit course – its structure, assignments, the evaluation of its impact, and the lessons learned from the experience. Through a review of current literature on data literacy instruction, we will examine the project's place within the larger framework of IL and explain the reasons for the library's engagement with it. Our critical analysis of scholarship on the topic and successful experimentation offer support for the argument that librarians can play a vital role in helping students develop and build data literacy competencies, transferable to academic and professional contexts. However, to accomplish this, we also suggest librarians need to upskill and rethink IL instruction. The innovative practice described below may be of use to librarians who are considering teaching or who want to expand their engagement with data literacy instruction.

2. Literature review

IL and library services have evolved over the past few decades. Emerging technologies like graphical creation tools, data management software, and access to vast quantities of data have offered new ways of working with information. In response to the changing information landscape, libraries engage in promoting meta-literacy skills, such as data and visual literacy. These literacies are increasingly seen as critical knowledge that students need to master to succeed in the world today (Carlson et al., 2015; D'Ignazio & Bhargava, 2018; Kim, 2016; Prado & Marzal, 2013; Shorish, 2015; Stephenson & Caravello, 2007). To better prepare for the future and improve their odds of getting hired, undergraduates should add data and visual literacy skills to their toolbox.

Who in academia can help students develop these competencies? While faculty appear to be one obvious resource, they have varying levels of knowledge of and interest in the technology necessary to support students in developing the skills of data analysis and data visualisation, which leads to challenges. In surveys conducted with faculty and students concerning instruction that depended on data literacy, there was a disconnect between the skills faculty assumed students had, and student uncertainty about how to learn specialised skills (Carlson et al., 2011). This obvious skill gap presents a window of opportunity for libraries. Librarians, due to their expertise in the area of IL, are well-positioned to expand their teaching to include data and visual literacy. Prado and Marzal (2013) affirm that 'several authors have called upon librarians, particularly university librarians, to further data literacy in information literacy training programs' (p. 124). For decades, librarians have built their professional abilities in IL and became recognised as experts. It is logical to capitalise on the knowledge and services already offered.

Being affiliated with an American academic library, our instructional activities are guided by reference documents developed by the Association of College & Research Libraries (ACRL), such as *Framework for Information Literacy for Higher Education* (2016) and *Visual Literacy*

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Competency Standards for Higher Education (2011). Although these are well-written documents, they do not quite address literacies associated with emerging information practices. The first document does not clearly define data literacy and its place in relation to IL. The latter 'focuses more on the interpretation and use of visual imagery and media outside of the data context' (Womack, 2014, p. 14). Even though there are no formally developed ACRL data literacy standards, there has been some work done by librarians in this area. Post-secondary libraries are beginning to include a number of aspects of data literacy in their instructional programs. Dai (2019) confirms that 'data literacy, and its variations (data information literacy, research data literacy and science data literacy in terms of terminology), has been viewed by the library community as a subset, or extension, of information literacy' (p. 2).

Furthermore, there has been considerable work on the development of what constitutes data literacy competencies. This work has been focused on skills, such as finding and evaluating data, data documentation, preservation, and sharing (Shorish, 2015). Prado and Marzal (2013) interpret them as 'a suite of data acquisition-, evaluation-, handling-, analysis- and interpretation-related competencies' (p. 124). Dai (2019) considers three approaches to data literacy, of which the first one – 'critical thinking applied to evaluating data sources and formats and interpreting and communicating findings' (p. 2) – resonates the most with undergraduate education. Basically, what emerges from the body of literature is that data literacy becomes an essential competency, and its inclusion in libraries' instructional programs allows 'libraries to contribute to both data and information literacy, as part of their mission to further knowledge and innovation' (Prado & Marzal, 2013, p. 123). The demands on students, as they advance in their studies and then enter the workforce, make it essential that librarians help them to develop these skills.

An important aspect of discussions about data literacy is the role and value of data visualisation. This is one of the many different competencies associated with data literacy (NAS Colloquia, 2018; Womack, 2014). Since emerging technologies place a great emphasis on visual information, data visualisation becomes a preferred way to communicate. Business and governmental organisations make expansive arguments using data-driven visualisations when evaluating operations and making decisions (Few & Edge, 2007). Therefore, the need arises for students to have a certain level of proficiency in how to 'speak' data and make it an important component of data literacy.

As mentioned earlier, based on the growing demands, data literacy and data visualisation are slowly being integrated into existing teaching. There are several studies describing different approaches that librarians take in teaching data literacy (Dai, 2019; Prado & Marzal, 2013; Shorish, 2015). Some scholars view teaching data literacy as part of IL (Dai, 2019; Prado & Marzal, 2013; Shorish, 2015; Womack, 2014). The literature asserts that the more impactful approaches to data literacy instruction have focused on librarians working directly with students, either in the classroom, partnering with faculty, or through providing workshops and specialised instruction (Dai, 2019). Data literacy is concurrently offered through one-on-one consultations, reference desk instruction, drop-in sessions, and online tutorials (Prado & Marzal, 2013). There is no one uniform approach to ensure consistency of instruction. More often, data literacy is taught sporadically based on demand. There are credit courses taught by non-librarians but not much has been written about librarians delivering data literacy credit-bearing instruction.

Our review of existing literature shows that there is an acknowledgement of the growing importance of data and visual literacy, as well as recognition of the library as a key player in helping teach students these skills. Within this framework, our project aimed to offer students both an understanding of the concepts of data literacy and a set of practical skills built upon data literacy competencies.

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3. One-credit course on data visualisation and data literacy

We started our pilot project in the winter of 2019. The main objective of our initiative was to prepare students to be responsible readers of data, with a focus on finding, evaluating, interpreting, and synthesising information. We also wanted to develop effective communicators of information, via compelling data visualisations and storytelling with data. Our approach was the creation of a one-credit course that would allow us to spend substantial time delivering instruction and working hands-on with students. This was preferable to offering drop-in sessions since we could ensure attendance, provide more substantive instruction, and track student progress over time. We chose not to approach faculty to make it part of an existing course, since we wanted the material covered to be interdisciplinary, and preferred to focus student attention on data literacy and visualisation skills, independent of any other curricular priority that would exist with an embedded model.

The first task was to get approval from the curriculum committee. After the proposal was submitted to the committee and accepted in February 2019, the course was set to be taught in spring 2020. Our one-credit instruction would be offered face-to-face and spread over six weeks at the beginning of the term, with two hours per week for a total of 12.5 contact hours. To encourage active student engagement, we planned to incorporate a lot of active learning techniques and hands-on activities. To achieve this effectively, we kept the class size limited to 14 students.

In preparation for teaching, it was necessary to update our skills to ensure the quality of our instruction. We spent the summer becoming proficient in the tools we wanted students to use in the course. At the same time, we focused on reviewing professional literature, choosing course textbooks, taking numerous preparatory courses on data visualisation, and liaising with faculty from other universities teaching data visualisation courses. This preparation took a considerable amount of time and effort on our part, but it was an important step for us to get ready and build our confidence.

Interest in the course was high. After only a week of open registration, the course had filled up and there was a waitlist of four students. The registered cohort consisted predominantly of second-year undergraduates as well as two first-years and a final-year undergraduate.

To organise course content and facilitate communication with students, we created a new course in Canvas where we placed all instructional materials. The Canvas course was a single place for students to upload class assignments, take quizzes, review class presentations, get links to required readings and practice datasets.

We identified four learning outcomes for the course. On completion of the course, we expected students to be able to:

- Understand effective design principles and be able to apply them in visual communication.
- Grasp the concept of a dataset and know where to find and gather datasets as well as how to interpret them and generate informative visualisations.
- Use digital tools to organise and display quantitative and qualitative data.
- Incorporate effective visual design and data visualisation into personal and professional self-promotion.

Key topics were selected that we felt needed to be covered in the course, to ensure students not only learned basic principles of effective data visualisation and design, but also mastered relevant software, and could apply new skills to practical, real-life scenarios. In addition to these specific data and visual literacy skills, the course also aimed to improve student communication,

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analytical, and critical thinking skills. We wanted students to develop competencies that they could apply in any academic discipline as well as in their professional and personal life.

Classes were generally divided into two parts: the first half of the class was lecture-based, and the second half was devoted to discussions and hands-on practice. We also provided after-class assistance if students needed advice or help. The assigned readings were from two textbooks (Knaflic, 2015; Yau, 2013), complemented by several videos on data visualisation from LinkedIn Learning courses to accommodate different learning styles.

We scaffolded instruction to support student learning, breaking down the material into intelligible concepts and moving students gradually from simple to complex ideas. We trained them in some basic data literacy competencies: ability to access data, critically evaluate its quality on the grounds of authority and reliability, handle and analyse data, draw meaning, and present it elegantly and ethically.

At the beginning of the course, the focus was on preparing students to be savvy consumers of information. We shared several examples of misleading graphs and charts with students, and asked them to recognise bias and spot misrepresentations of data. Building on examples like this, we moved from evaluation to handling data. As the course progressed, students worked with data: accessing, appraising, interpreting, and processing it. To facilitate their engagement with data, we created a list of open and subscription-based data banks, such as the IMF (International Monetary Fund), UNdata, the World Bank, Data Planet, and others. While students explored data sources, we specifically focused on discussing the provenance of information to make them appraise data credibility and reliability. We also instructed them on how to cite data sources.

Data cleaning was another core skill introduced during the course. Data from government sources, non-profits, and even business agencies is not always ‘ready-to-use’. It requires some cleaning and understanding of what exactly it represents. Students learned the iterative process of how to locate and extract data, organise and analyse it, draw meaning, and gain new insights. The final outcome was to take raw data and transform it into attractive and impactful data visualisations.

To equip students with data visualisation competencies, we introduced students to two popular and widely used tools: Google Sheets and Excel. By the third class we transitioned to Venngage as principal software to create more complex visualisations, including maps and infographics. We assumed that not every student had a strong technical background, so we chose Venngage for its gentle learning curve. The software offered a variety of visualisation types that were easy to create; it did not require programming skills, and could be taught within the 12.5 contact hours. This made the product more appealing, knowing that a complex tool like Tableau, an interactive data visualisation software, could create obstacles for some students, and potentially discourage them from finishing the course. We wanted to provide students with essential knowledge of data analysis and visualisation and leave them empowered to explore more complex solutions and software tools on their own.

Our teaching approach was grounded in constructivist learning theories, ‘which view the learner as an active participant in constructing new knowledge’ (D’Ignazio & Bhargava, 2018, p. 28). While students gained core understanding of data visualisation principles through readings, we focused classroom activities on developing their practical skills. We asked students to complete assignments every week as we believe that the best learning happens through hands-on experience. In class, students created data visualisations following instructors' demonstrations and examples. At home, they continued to build their skills through more complex assignments related to class material.

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For the final project, students were asked to work in groups of two and research a topic of their own choice. We encouraged them to come up with topics that stimulated their curiosity, and simultaneously engaged them with broad issues that are socially important. Students were expected to find real-world datasets, construct a story through data analysis, and develop a compelling narrative using at least three to five distinct data visualisations. We wanted their storyboards to be aesthetically appealing and to follow the fundamental design principles (for example: no clutter, accent on important elements, focus on clarity, accuracy in data presentation). In the last class, students were given ten minutes per group to present their final projects. The table below shows the course outline.

Table 1: Outline of course topics and assignments

Lesson	Objectives	Activities
1. Data visualisation and basic design principles	Understand core concepts of effective design. Develop the ability to interpret and critically analyse charts. Generate charts in Google Sheets that accurately convey the meaning of data.	**In class**: evaluate and critique assigned graphs from the news media, spot misrepresentations of information. **Homework**: create the best-suited graphs in Google Sheets using provided data; complete online quiz.
2. Data discovery and processing: how to find, treat and cite data	Locate and utilise credible datasets. Evaluate the quality of data. Treat, clean and organise data. Create multivariable charts. Properly attribute data sources.	**In class:** clean a given dataset and prepare a multivariable visualisation. **Homework**: explore a list of data portals; pick one dataset, clean and organise it; create easy to understand graphs.
3. Charts, graphs, and maps. Using Venngage software	Understand the mechanics of the Venngage software. Generate various types of visualisations (graphs, timelines and maps) using the Venngage tool.	**In class:** use Venngage to create graphs and geo-visualisations from provided datasets. **Homework:** use Venngage and create a graph and a geo-visualisation from a real-world dataset.
4. Storytelling with Data	Sharpen skills of information presentation in Venngage. Create infographics. Become familiar with Venngage templates.	**In class:** create infographics in Venngage using provided data. **Homework:** choose a dataset and create an infographic in Venngage; conceptualise the final project, conduct exploratory data research and analysis, write a short synopsis of the idea.
5. Tools for independent learning and skill building	Understand the importance of the LinkedIn profile and identify ways to enhance an online web portfolio. Build a data visualisation dashboard in Venngage.	**In class:** present the 'elevator pitch' project proposal, seek feedback and ideas for improvement. **Homework:** prepare the final project – visual presentations of data applying data visualisation best practices.

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6. Final projects presentation. Wrap-up and course assessment	Present a storyboard with visualisations of insights gained from data analysis. Effectively communicate the connection between visualisations following the narrative thread.	**In class:** present the project; participate in a course wrap-up discussion; complete the course survey.

Here are examples of final projects presented by students.

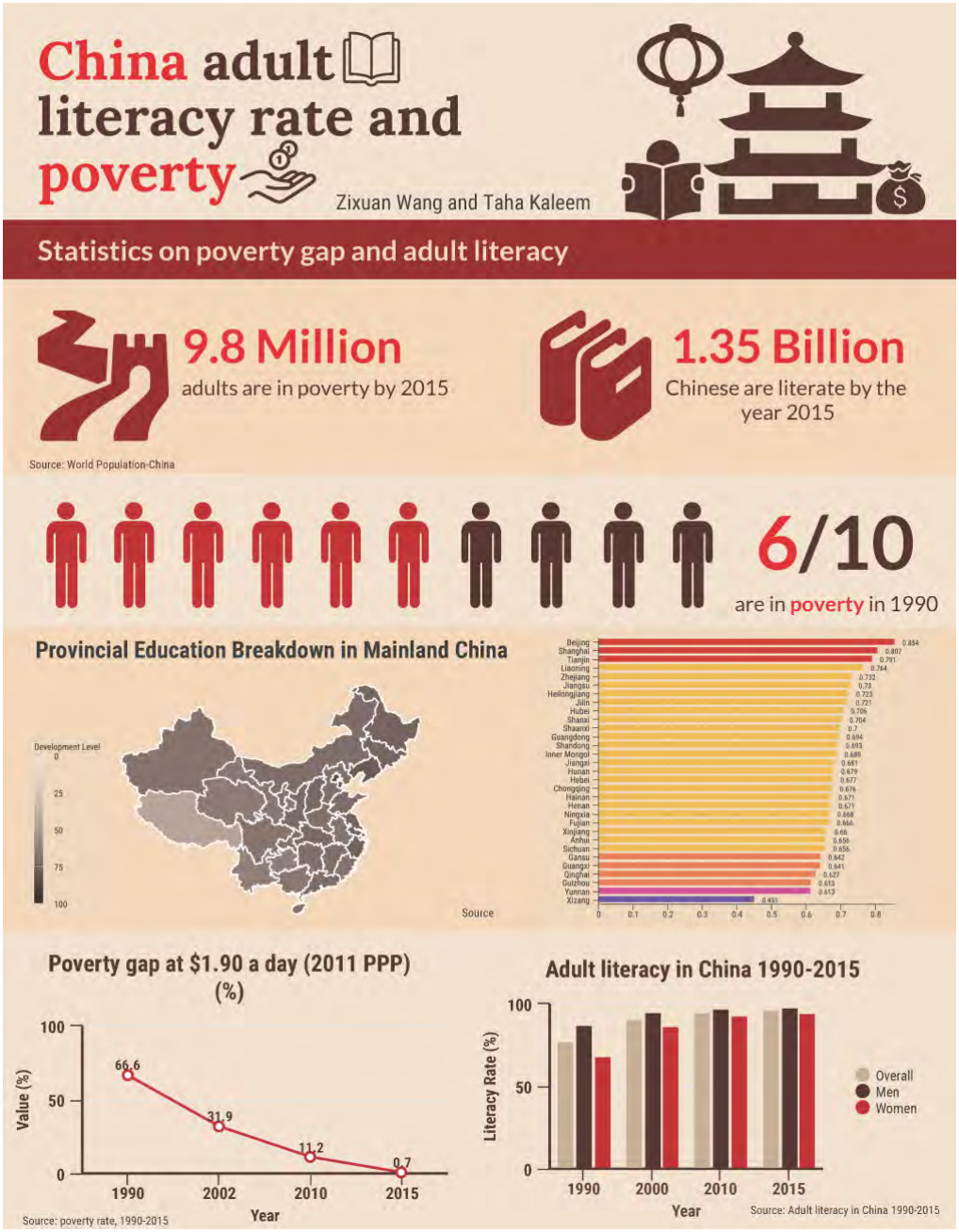

Figure 1: China Adult Literacy and Poverty project - image by Zixuan Wang and Taha Kaleem, licensed under CC BY-SA.

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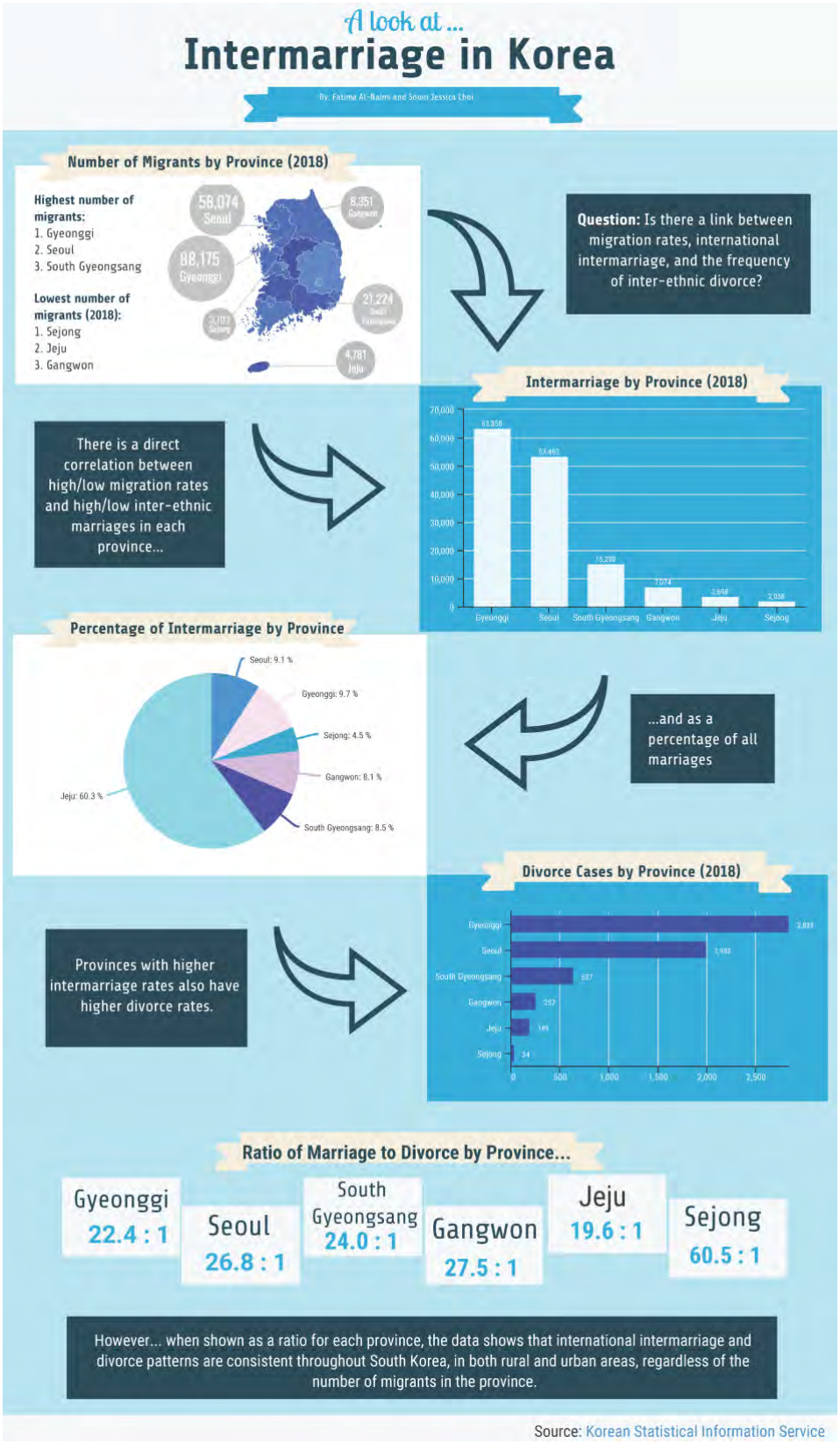

Figure 2: A Look at Intermarriage in Korea project - image by Sooin Jessica Choi and Fatima Al-Naimi, licensed under CC BY-SA.

Throughout the course, we collected student feedback and made efforts to improve our teaching. We monitored the students' progress in reaching the learning outcomes set for the

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course by evaluating homework assignments and the final project. Assessment of in-class activities and homework proved to be valuable. We noted that with each session, the students became more comfortable with the online tools and the assignments. The course grade was pass-fail, and all of the students enrolled successfully completed it. As an opportunity to provide their opinion on the course, students were sent a link to fill out an electronic course-evaluation survey.

4. Feedback and reflections

4.1 Student feedback

We collected valuable insights from the final debrief conversation and course evaluations. In the debrief conversation at the end of the course, students expressed their overall satisfaction with the course content and delivery. They felt they gained skills that would increase their preparedness for upper level courses and enhance their chances of finding future employment.

Ten out of 14 students (over 70%) completed the institution's anonymous course-evaluation questionnaire. Overall, the feedback was very positive. Students described the course as 'interesting and immersive'. They gave 4.4 on a five-point scale when asked, 'Is the quality of classroom presentation stimulating (consider the effectiveness of discussions, demonstrations, and lectures)?', and 4.1 points for the question, 'To what degree were the stated objectives of the course met?' Participants also commented positively on the instructors' preparedness for the class, the quality of classroom presentations, and the stimulating nature of the materials, which 'encouraged them to do the best work.' They liked our hands-on approach and found the homework assignments helpful.

Students also suggested some improvements. For example, one student noted that, 'classes about finding the data sets from the sources were very dry.' Another student was not happy with the Venngage software and noted, 'I would have preferred it if we tried more sophisticated software … a more advanced approach to data visualisation would have been more enriching.' We recognise this limitation in our approach. Our challenge was that, due to the small number of contact hours, teaching a more complex tool like Tableau was not feasible. In addition, we dealt with a range of student technical abilities. Undergraduates at our university are usually expected to acquire technical skills on their own. Because the curriculum at our institution is writing-intensive, students rarely engage in challenging, technology-based activities during their studies. Our student cohort had clear differences in their technical and critical thinking skills. This presented us with a challenge since we needed to keep the class interesting for more advanced students, while offering support to participants who struggled with certain aspects of the course. The skill disparity became evident when we reviewed their homework and class assignments. The quality of graphs varied, as well as the handling of data. Not all students managed to find pertinent datasets and make sense of numeric data. However, all of the participants developed a deep understanding of concepts and became comfortable with the technology used during the course. Overall, the students succeeded in submitting good quality projects. It was fascinating to see how they managed to apply existing knowledge to new concepts, how creative they were in finding information and how eager they were to experiment. The range of topics submitted for the final project was broad and surprisingly captivating. It was gratifying to see the final works.

The student feedback was very important and will help us improve instruction and make the learning experience more relevant to students' needs. In general, we saw great interest in the course. Students crave the opportunity to learn practical skills that enhance academic work and expand career prospects. Our one-credit course gave them a taste of data analysis and visualisation, and it was clear they wanted more. One student commented, "I would also recommend that the class should be extended to an entire semester. For example, after

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Venngage we could have moved on to another software because these computer skills are crucial in this day and age."

4.2 Future directions

Moving forward, there are several paths we can take to develop the course in the future. To provide students with deeper experience of data management and visualisation, we may consider:

- continuing a one-credit course with improved instruction based on student feedback;
- offering two one-credit bearing courses: one at a basic level and one more advanced;
- exploring opportunities to teach a three-credit course with enhanced content, and more sophisticated technology tools such as Tableau;
- collaborating with a faculty member on course-integrated instruction that will allow students to master data literacy skills based on the course content. The syllabus will be developed together with faculty, and teaching will be shared.

We realise that teaching a semester-long course would be a good option. We could cover more material and ensure that students mastered data processing and data visualisation skills. Moreover, a traditionally graded course tends to be more appealing to students than a pass-fail course. However, offering a stand-alone course led by librarians is probably not the ideal method of teaching, given competing demands for librarians' time and the lack of faculty status for librarians at our institution.

An alternative option would be to teach the course in tandem with a faculty member. The data literacy examples could be tailored to the course subject, allowing students to contextualise their new information skills. However, this option has its own set of challenges. First, there is the challenge of faculty outreach. The chances of establishing a collaborative teaching scenario are heavily dependent on faculty receptiveness to such an idea. Second, present academic culture tends to separate IL teaching from disciplinary teaching (Maybee et al., 2015). Given our circumstances, it would be difficult to get a buy-in for a three-credit course from faculty and the curriculum committee.

In the context of our institution and given the challenges listed above, offering a one-credit course by librarians is presently a more feasible option moving forward.

4.3 Upskilling librarians

An important takeaway is the necessity for librarians to upskill in the emergent area of data literacy and associated technology tools. IL has served librarians well, but it is important to grow with societal changes. Data literacy is a good example of an area where librarians can expand the services they offer and develop competencies in order to teach students. Likewise, librarians can learn new technology tools and software. The important point is that librarians cannot afford to let technology pass them by if they want to remain relevant in the evolving higher education ecosystem.

Presented with an opportunity to fill a niche, we can leverage our expertise, and find effective solutions to increase librarians' involvement in data literacy instruction. What form it will ultimately take depends on the institutional context and the buy-in of librarians.

5. Conclusion

In the data-driven world, teaching data literacy becomes imperative. As argued, librarians are well positioned to offer instruction in this field, and it fits well with our role in teaching IL. Furthermore, it will strengthen our position as recognised information experts. Considering our

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experience from the one-credit course pilot, we believe libraries should take on more opportunities to become involved in teaching data literacy. The implementation can take different forms, depending on the institutional setting and existing programming. Our recommendation is to extend librarians' engagement beyond the traditional one-shot instructional model into credit-based, specialised data-literacy instruction.

Taking a leadership role in data literacy requires an investment of time and effort. Librarians need further training to develop an advanced skill set necessary to teach data literacy with confidence:

> There is always the question, how 'literate' we, librarians and technologists, should be in order to teach others data literacy. Part of this question concerns the tools. The question puts more pressure on professionals nowadays as the field and industry of data science are advancing daily; this anxiety and need to upgrade ourselves constantly is real (Dai, 2019, p. 8).

It will take some effort to upskill ourselves and become proficient with new technologies but the result is worth it.

Finally, to encourage broader adoption of new practices in academic libraries, a set of standards for data literacy and data visualisation is needed. It would establish norms and guide our instructional activities. The world is evolving, and so should our approach to developing undergraduate competencies. Librarians can make a solid contribution to growing a generation of active citizens who think critically, understand information, find reliable sources, use data ethically, and do not allow others to manipulate their opinion.

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